# BEST AVAILABLE IMAGES

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# PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

| Applicant's or agent's file reference | FOR FURTHER ACTION | see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below. |
|---|---|---|
| 100342 | | |
| International application No. | International filing date *(day/month/year)* | (Earliest) Priority Date *(day/month/year)* |
| PCT/AU00/01022 | 29 August 2000 | 3 September 1999 |

Applicant

PACIFIC ORE TECHNOLOGY (AUSTRALIA) LTD et al

This international search report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This international search report consists of a total of 4 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

[ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing:

[ ] contained in the international application in written form.

[ ] filed together with the international application in computer readable form.

[ ] furnished subsequently to this Authority in written form.

[ ] furnished subsequently to this Authority in computer readable form.

[ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

[ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (See Box II).

4. With regard to the **title**,

[X] the text is approved as submitted by the applicant.

[ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

[X] the text is approved as submitted by the applicant

[ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 1

[X] as suggested by the applicant.

[ ] None of the figures

[ ] because the applicant failed to suggest a figure

[ ] because this figure better characterizes the invention

Copy for the Elected Office (EO/US)

PCT/AU00/01022

# PATENT COOPERATION TREATY

## PCT

From the INTERNATIONAL BUREAU

To:

WRAY & ASSOCIATES
239 Adelaide Terrace
Perth, W.A. Australia 6000
AUSTRALIE

### NOTIFICATION OF THE RECORDING OF A CHANGE

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

| | |
|---|---|
| Date of mailing (day/month/year)<br>14 February 2002 (14.02.02) | |
| Applicant's or agent's file reference<br>100342 | **IMPORTANT NOTIFICATION** |
| International application No.<br>PCT/AU00/01022 | International filing date (day/month/year)<br>29 August 2000 (29.08.00) |

1. The following indications appeared on record concerning:

☐ the applicant ☐ the inventor ☐ the agent ☐ the common representative

| Name and Address | State of Nationality | State of Residence |
|---|---|---|
| | Telephone No. | |
| | Facsimile No. | |
| | Teleprinter No. | |

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:

☒ the person ☐ the name ☐ the address ☐ the nationality ☐ the residence

| Name and Address | State of Nationality | State of Residence |
|---|---|---|
| PURKISS, Simon, Anthony, Roger<br>15 Woodend Drive<br>South Ascot SI5 9BD<br>United Kingdom | GB | GB |
| | Telephone No. | |
| | Facsimile No. | |
| | Teleprinter No. | |

3. Further observations, if necessary:
**The above applicant has been recorded as applicant/inventor for the United States of America only.**

4. A copy of this notification has been sent to:

☒ the receiving Office
☐ the International Searching Authority
☐ the International Preliminary Examining Authority
☐ the designated Offices concerned
☒ the elected Offices concerned
☐ other:

| | |
|---|---|
| The International Bureau of WIPO<br>34, chemin des Colombettes<br>1211 Geneva 20, Switzerland<br>Facsimile No.: (41-22) 740.14.35 | Authorized officer<br>Jean-Luc MARTIN<br>Telephone No.: (41-22) 338.83.38 |

Form PCT/IB/306 (March 1994)

004663761

**INTERNATIONAL SEARCH REPORT**

International application No.
PCT/AU00/01022

**A. CLASSIFICATION OF SUBJECT MATTER**

Int. Cl. [7]: C22B 3/18

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)
IPC C22B 3/18, 3/00, 15/00, 11/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC AS ABOVE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DERWENT WPAT

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | WO 92/16667 A (BAC TECH (AUSTRALIA) PTY. LTD.) 1 October 1992<br>see page 3 lines 1-9 | 1-7,9,13,15-17 |
| X | US 4729788 A (HUTCHINS et al) 8 March 1988<br>see column 3 line 52-column 4 line 15 | 1-3,5-7,9,13,15-17 |
| X | AU 78560/98 A (THE UNIVERSITY OF QUEENSLAND et al)<br>11 February 1999<br>see page 9 lines 17-22 | 13-16 |

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search
24 October 2000

Date of mailing of the international search report
1 NOV 2000

Name and mailing address of the ISA/AU

AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
E-mail address: pct@ipaustralia.gov.au
Facsimile No. (02) 6285 3929

Authorized officer

MATTHEW FRANCIS
Telephone No : (02) 6283 2424

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU00/01022

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | WO 98/51827 A (ECHO BAY MINES, LIMITED) 19 November 1998<br>see page 10 line 9-page 11 line 2, claim 12 | 1-10,13-17 |
| X | WO 94/28184 A (MIM HOLDINGS LIMITED) 8 December 1994<br>see page 12 lines 30-38 | 1-9,13-17 |
| X | AU 59647/98 (714364) B (BILLITON SA LIMITED) 1 October 1998<br>see page 6 lines 10-14 | 1-8,13-17 |

**INTERNATIONAL SEARCH REPORT**
Information on patent family members

International application No.
**PCT/AU00/01022**

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

| Patent Document Cited in Search Report | | Patent Family Member | | | | | |
|---|---|---|---|---|---|---|---|
| WO | 9216667 | AP | 379 | AU | 14227/92 | AU | 87890/98 |
| | | BG | 98117 | US | 5429659 | ZA | 9202051 |
| | | ZW | 46/92 | AU | 98269/98 | | |
| US | 4729788 | AU | 10328/88 | CA | 1308916 | ZA | 8800071 |
| AU | 78560/98 | NONE | | | | | |
| WO | 9851827 | AU | 76709/98 | US | 5873927 | US | 6096113 |
| | | WO | 200050651 | | | | |
| WO | 9428184 | AU | 67896/94 | | | | |
| AU | 59647/98 | CA | 2233417 | CN | 1210152 | US | 5919674 |
| | | ZA | 9802549 | | | | |

END OF ANNEX

**PCT REQUEST**

100342

Original (for **SUBMISSION**) - printed on 29.08.2000 10:14:38 AM

| | | |
|---|---|---|
| 0 | **For receiving Office use nly** | |
| 0-1 | International Application No. | |
| 0-2 | International Filing Date | 10/070246 |
| 0-3 | Name of receiving Office and "PCT International Application" | |

| | | |
|---|---|---|
| 0-4 | **Form - PCT/RO/101 PCT Request** | |
| 0-4-1 | Prepared using | PCT-EASY Version 2.91 (updated 01.07.2000) |
| 0-5 | **Petition** The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty | |
| 0-6 | **Receiving Office (specified by the applicant)** | Australian Patent Office (RO/AU) |
| 0-7 | **Applicant's or agent's file reference** | 100342 |
| I | **Title of invention** | IMPROVED BACTERIAL OXIDATION OF SULPHIDE ORES AND CONCENTRATES |
| II | **Applicant** | |
| II-1 | This person is: | applicant only |
| II-2 | Applicant for | all designated States except US |
| II-4 | Name | PACIFIC ORE TECHNOLOGY (AUSTRALIA) LTD |
| II-5 | Address: | First Floor<br>24 Outram Street<br>West Perth, Western Australia 6005<br>Australia |
| II-6 | State of nationality | AU |
| II-7 | State of residence | AU |
| II-8 | Telephone No. | 08 9481 6040 |
| II-9 | Facsimile No. | 08 9481 6035 |
| III-1 | **Applicant and/or inventor** | |
| III-1-1 | This person is: | applicant and inventor |
| III-1-2 | Applicant for | US only |
| III-1-4 | Name (LAST, First) | HUNTER, Colin, John |
| III-1-5 | Address: | 14 Viking Road<br>Dalkeith, Western Australia 6009<br>Australia |
| III-1-6 | State of nationality | GB |
| III-1-7 | State of residence | GB |

**PCT REQUEST**

100342

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| | | |
|---|---|---|
| III-2 | **Applicant and/or inventor** | |
| III-2-1 | This person is: | applicant and inventor |
| III-2-2 | Applicant for | US only |
| III-2-4 | Name (LAST, First) | WILLIAMS, Tamsin, Lisa |
| III-2-5 | Address: | 4/24 Caledonian Avenue<br>Maylands, Western Australia 6051<br>Australia |
| III-2-6 | State of nationality | AU |
| III-2-7 | State of residence | AU |
| III-3 | **Applicant and/or inventor** | |
| III-3-1 | This person is: | applicant only |
| III-3-2 | Applicant for | all designated States except US |
| III-3-4 | Name (LAST, First) | PURKISS, Simon, Anthony, Roger |
| III-3-5 | Address: | 15 Woodend Drive<br>South Ascot, SL5 9BD<br>United Kingdom |
| III-3-6 | State of nationality | GB |
| III-3-7 | State of residence | GB |
| III-4 | **Applicant and/or inventor** | |
| III-4-1 | This person is: | applicant and inventor |
| III-4-2 | Applicant for | US only |
| III-4-4 | Name (LAST, First) | CHEUNG, Leo, Wai-Chiu |
| III-4-5 | Address: | 44 Prestige Drive<br>Lincoln, New Brunswick E3B 7J1<br>Canada |
| III-4-6 | State of nationality | CN |
| III-4-7 | State of residence | CA |
| III-5 | **Applicant and/or inventor** | |
| III-5-1 | This person is: | applicant and inventor |
| III-5-2 | Applicant for | US only |
| III-5-4 | Name (LAST, First) | CONNORS, Elena |
| III-5-5 | Address: | 110 Kilarney Road<br>Fredericton, New Brunswick E3A 5G8<br>Canada |
| III-5-6 | State of nationality | CA |
| III-5-7 | State of residence | CA |
| III-6 | **Applicant and/or inventor** | |
| III-6-1 | This person is: | applicant and inventor |
| III-6-2 | Applicant for | US only |
| III-6-4 | Name (LAST, First) | GLIDERS, Ross, David |
| III-6-5 | Address: | 31 Pine Ridge Avenue<br>New Maryland, New Brunswick E3C 1C6<br>Canada |
| III-6-6 | State of nationality | CA |
| III-6-7 | State of residence | CA |

PCT REQUEST

100342

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| | | |
|---|---|---|
| IV-1 | **Agent or common representative; or address for correspondence**<br>The person identified below is hereby/has been appointed to act on behalf of the applicant(s) before the competent International Authorities as: | agent |
| IV-1-1 | Name | WRAY & ASSOCIATES |
| IV-1-2 | Address: | 239 Adelaide Terrace<br>Perth, Western Australia 6000<br>Australia |
| IV-1-3 | Telephone No. | 08 9325 6122 |
| IV-1-4 | Facsimile No. | 08 9325 2883 |
| IV-1-5 | e-mail | wray@wray.com.au |
| V | **Designation of States** | |
| V-1 | Regional Patent<br>(other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned) | AP: GH GM KE LS MW MZ SD SL SZ TZ UG ZW and any other State which is a Contracting State of the Harare Protocol and of the PCT<br>EA: AM AZ BY KG KZ MD RU TJ TM and any other State which is a Contracting State of the Eurasian Patent Convention and of the PCT<br>EP: AT BE CH&LI CY DE DK ES FI FR GB GR IE IT LU MC NL PT SE and any other State which is a Contracting State of the European Patent Convention and of the PCT<br>OA: BF BJ CF CG CI CM GA GN GW ML MR NE SN TD TG and any other State which is a member State of OAPI and a Contracting State of the PCT |
| V-2 | National Patent<br>(other kinds of protection or treatment, if any, are specified between parentheses after the designation(s) concerned) | AE AG AL AM AT AU AZ BA BB BG BR BY BZ CA CH&LI CN CR CU CZ DE DK DM DZ EE ES FI GB GD GE GH GM HR HU ID IL IN IS JP KE KG KP KR KZ LC LK LR LS LT LU LV MA MD MG MK MN MW MX MZ NO NZ PL PT RO RU SD SE SG SI SK SL TJ TM TR TT TZ UA UG US UZ VN YU ZA ZW |
| V-5 | **Precautionary Designation Statement**<br>In addition to the designations made under items V-1, V-2 and V-3, the applicant also makes under Rule 4.9(b) all designations which would be permitted under the PCT except any designation(s) of the State(s) indicated under item V-6 below. The applicant declares that those additional designations are subject to confirmation and that any designation which is not confirmed before the expiration of 15 months from the priority date is to be regarded as withdrawn by the applicant at the expiration of that time limit. | |
| V-6 | **Exclusion(s) from precautionary designations** | NONE |

PCT REQUEST

100342

Original (for SUBMISSION) - printed on 29.08.2000 10:14:38 AM

| | | | |
|---|---|---|---|
| VI-1 | **Priority claim of earlier national application** | | |
| VI-1-1 | Filing date | 03 September 1999 (03.09.1999) | |
| VI-1-2 | Number | PQ2651 | |
| VI-1-3 | Country | AU | |
| VI-2 | **Priority document request** The receiving Office is requested to prepare and transmit to the International Bureau a certified copy of the earlier application(s) identified above as item(s): | VI-1 | |
| VII-1 | **International Searching Authority Chosen** | Australian Patent Office (ISA/AU) | |
| VIII | **Check list** | number of sheets | electronic file(s) attached |
| VIII-1 | Request | 5 | - |
| VIII-2 | Description | 16 | - |
| VIII-3 | Claims | 3 | - |
| VIII-4 | Abstract | 1 | pacific.txt |
| VIII-5 | Drawings | 1 | - |
| VIII-7 | TOTAL | 26 | |
| | **Accompanying items** | paper document(s) attached | electronic file(s) attached |
| VIII-8 | Fee calculation sheet | ✓ | - |
| VIII-16 | PCT-EASY diskette | - | diskette |
| VIII-18 | **Figure of the drawings which should accompany the abstract** | 1 | |
| VIII-19 | **Language of filing of the international application** | English | |
| IX-1 | **Signature of applicant or agent** | | |
| IX-1-1 | Name | WRAY & ASSOCIATES | |
| IX-1-2 | Name of signatory | Peter M Caporn | |
| IX-1-3 | Capacity | Patent Attorney | |

## FOR RECEIVING OFFICE USE ONLY

| | | |
|---|---|---|
| 10-1 | **Date of actual receipt of the purported international application** | |
| 10-2 | **Drawings:** | |
| 10-2-1 | Received | |
| 10-2-2 | Not received | |
| 10-3 | **Corrected date of actual receipt due to later but timely received papers or drawings completing the purported international application** | |
| 10-4 | **Date of timely receipt of the required corrections under PCT Article 11(2)** | |
| 10-5 | **International Searching Authority** | ISA/AU |
| 10-6 | **Transmittal of search copy delayed until search fee is paid** | |

PCT REQUEST

100342

Original (for **SUBMISSION**) - printed on 29.08.2000 10:14:38 AM

## FOR INTERNATIONAL BUREAU USE ONLY

| | | |
|---|---|---|
| 11-1 | Date of receipt of the record copy by the International Bureau | |

PCT/AU00/01022

# PATENT COOPERATION TREATY

## PCT

**NOTIFICATION OF THE RECORDING OF A CHANGE**

(PCT Rule 92bis.1 and Administrative Instructions, Section 422)

From the INTERNATIONAL BUREAU

To:

WRAY & ASSOCIATES
239 Adelaide Terrace
Perth, W.A. Australia 6000
AUSTRALIE

| | |
|---|---|
| Date of mailing (day/month/year): 14 February 2002 (14.02.02) | |
| Applicant's or agent's file reference: 100342 | IMPORTANT NOTIFICATION |
| International application No.: PCT/AU00/01022 | International filing date (day/month/year): 29 August 2000 (29.08.00) |

1. The following indications appeared on record concerning:
☐ the applicant ☐ the inventor ☐ the agent ☐ the common representative

Name and Address

State of Nationality | State of Residence

Telephone No.

Facsimile No.

Teleprinter No.

2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:
☒ the person ☐ the name ☐ the address ☐ the nationality ☐ the residence

Name and Address
PURKISS, Simon, Anthony, Roger
15 Woodend Drive
South Ascot SI5 9BD
United Kingdom

State of Nationality: GB | State of Residence: GB

Telephone No.

Facsimile No.

Teleprinter No.

3. Further observations, if necessary:
**The above applicant has been recorded as applicant/inventor for the United States of America only.**

4. A copy of this notification has been sent to:
☒ the receiving Office
☐ the International Searching Authority
☐ the International Preliminary Examining Authority
☐ the designated Offices concerned
☒ the elected Offices concerned
☐ other:

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Facsimile No.: (41-22) 740.14.35

Authorized officer
Jean-Luc MARTIN
Telephone No.: (41-22) 338.83.38

Form PCT/IB/308 (March 1994)

004663761

*The demand must be filed directly with the competent International Preliminary Examining Authority. If two or more Authorities are competent, with the one chosen by the applicant. The full name or two-letter code of that Authority may be indicated by the applicant on the line below:*

IPEA/ _____

# PCT

**CHAPTER II**

## DEMAND

under Article 31 of the Patent Cooperation Treaty:
The undersigned requests that the international application specified below be the subject of international preliminary examination according to the Patent Cooperation Treaty and hereby elects all eligible States (except where otherwise indicated).

For International Preliminary Examining Authority use only

| Identification of IPEA | Date of receipt of DEMAND |
|---|---|
| | |

**Box No. I IDENTIFICATION OF THE INTERNATIONAL APPLICATION**

Applicant's or agent's file reference: 100342

| International application No. | International filing date *(day/month/year)* | (Earliest) Priority date *(day/month/year)* |
|---|---|---|
| PCT/AU00/01022 | 29 August 2000 (29.08.00) | 3 September 1999 (03.09.1999) |

Title of invention: IMPROVED BACTERIAL OXIDATION OF SULPHIDE ORES AND CONCENTRATES

**Box No. II APPLICANT(S)**

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

PACIFIC ORE TECHNOLOGY (AUSTRALIA) LTD
First Floor
24 Outram Street
West Perth, Western Australia 6005
Australia

Telephone No.: (08) 9481 6040
Facsimile No.: (08) 9481 6035
Teleprinter No.:

| State *(that is, country)* of nationality: | State *(that is, country)* of residence: |
|---|---|
| AU | AU |

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

HUNTER, Colin, John
14 Viking Road
Dalkeith, Western Australia 6007
Australia

| State *(that is, country)* of nationality: | State *(that is, country)* of residence: |
|---|---|
| GB | GB |

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

WILLIAMS, Tamsin, Lisa
4/24 Caledonian Avenue
Maylands, Western Australia 6051
Australia

| State *(that is, country)* of nationality: | State *(that is, country)* of residence: |
|---|---|
| AU | AU |

[X] Further applicants are indicated on a continuation sheet.

Sheet No. 2

International application No.
PCT/AU00/01022

**Continuation of Box No. II APPLICANT(S)**

***If none of the following sub-boxes is used, this sheet should not be included in the demand.***

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*
PURKISS, Simon, Anthony, Roger
15 Woodend Drive
South Ascot, SL5 9BD
United Kindom

| State *(that is, country)* of nationality: | State *(that is, country)* of residence: |
|---|---|
| GB | GB |

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*
CHEUNG, Leo, Wai-Chiu
44 Prestige Drive
Lincoln, New Brunswick E3B 7J1
Canada

| State *(that is, country)* of nationality: | State *(that is, country)* of residence: |
|---|---|
| CN | CA |

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*
CONNORS, Elena
110 Kilarney Road
Fredericton, New Brunswick E3A 5G8
Canada

| State *(that is, country)* of nationality: | State *(that is, country)* of residence: |
|---|---|
| CA | CA |

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*
GILDERS, Ross, David
31 Pine Ridge Avenue
New Maryland, New Brunswick E3C 1C6
Canada

| State *(that is, country)* of nationality: | State *(that is, country)* of residence: |
|---|---|
| CA | CA |

☐ Further applicants are indicated on another continuation sheet.

International application No.
PCT/AU00/01022

**Box No. III AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE**

The following person is [x] agent [ ] common representative

and [x] has been appointed earlier and represents the applicant(s) also for international preliminary examination.

[ ] is hereby appointed and any earlier appointment of (an) agent(s)/common representative is hereby revoked.

[ ] is hereby appointed, specifically for the procedure before the International Preliminary Examining Authority, in addition to the agent(s)/common representative appointed earlier.

Name and address: *(Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)*

WRAY & ASSOCIATES
Patent Attorneys
Level 6
239 Adelaide Terrace
Perth, Western Australia 6000
Australia

Telephone No.: (08) 9325 6122

Facsimile No.: (08) 9325 2883

Teleprinter No.:

[ ] **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special addr ess to which correspondence should be sent.

**Box No. IV BASIS FOR INTERNATIONAL PRELIMINARY EXAMINATION**

**Statement concerning amendments:***

1. The applicant wishes the international preliminary examination to start on the basis of:

[ ] the international application as originally filed

the description [x] as originally filed
[ ] as amended under Article 34

the claims [ ] as originally filed
[ ] as amended under Article 19 (together with any accompanying statement)
[x] as amended under Article 34

the drawings [x] as originally filed
[ ] as amended under Article 34

2. [ ] The applicant wishes any amendment to the claims under Article 19 to be considered as reversed.

3. [ ] The applicant wishes the start of the international preliminary examination to be postponed until the expiration of 20 months from the priority date unless the International Preliminary Examining Authority receives a copy of any amendments made under Article 19 or a notice from the applicant that he does not wish to make such amendments (Rule 69.1(d)). *(This check-box may be marked only where the time limit under Article 19 has not yet expired.)*

* Where no check-box is marked, international preliminary examination will start on the basis of the international application as originally filed or, where a copy of amendments to the claims under Article 19 and/or amendments of the international application under Article 34 are received by the International Preliminary Examining Authority before it has begun to draw up a written opinion or the international preliminary examination report, as so amended.

**Language for the purposes of international preliminary examination:** English

[x] which is the language in which the international application was filed.
[ ] which is the language of a translation furnished for the purposes of international search.
[ ] which is the language of publication of the international application.
[ ] which is the language of the translation (to be) furnished for the purposes of international preliminary examination.

**Box No. V ELECTION OF STATES**

The applicant hereby elects all eligible States *(that is, all States which have been designated and which are bound by Chapter II of the PCT)*

excluding the following States which the applicant wishes not to elect:



*See Notes to the demand form*

Sheet No. 4

International application No.
PCT/AU00/01022

**Box No. VI CHECK LIST**

| The demand is accompanied by the following elements, in the language referred to in Box No. IV, for the purposes of international preliminary examination: | | | For International Preliminary Examining Authority use only: received | not received |
|---|---|---|---|---|
| 1. translation of international application | : | sheets | ☐ | ☐ |
| 2. amendments under Article 34 | : 2 | sheets | ☐ | ☐ |
| 3. copy (or, where required, translation) of amendments under Article 19 | : | sheets | ☐ | ☐ |
| 4. copy (or, where required, translation) of statement under Article 19 | : | sheets | ☐ | ☐ |
| 5. letter | : 1 | sheets | ☐ | ☐ |
| 6. other *(specify)* | : | sheets | ☐ | ☐ |

The demand is also accompanied by the item(s) marked below:

1. [x] fee calculation sheet
2. [ ] separate signed power of attorney
3. [ ] copy of general power of attorney; reference number, if any:
4. [ ] statement explaining lack of signature
5. [ ] nucleotide and or amino acid sequence listing in computer readable form
6. [ ] other *(specify)*:

**Box No. VII SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE**

*Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the demand).*

Peter M Caporn
Patent Attorney

For International Preliminary Examining Authority use only

1. Date of actual receipt of DEMAND:
2. Adjusted date of receipt of demand due to CORRECTIONS under Rule 60.1(b):
3. ☐ The date of receipt of the demand is AFTER the expiration of 19 months from the priority date and item 4 or 5, below, does not apply. ☐ The applicant has been informed accordingly.
4. ☐ The date of receipt of the demand is WITHIN the period of 19 months from the priority date as extended by virtue of Rule 80.5.
5. ☐ Although the date of receipt of the demand is after the expiration of 19 months from the priority date, the delay in arrival is EXCUSED pursuant to Rule 82.

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Demand received from IPEA on:

# PATENT COOPERATION TREATY

# PCT

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

| | | |
|---|---|---|
| Applicant's or agent's file reference<br>100342 | **FOR FURTHER ACTION** | See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416). |
| International Application No.<br>**PCT/AU00/01022** | International Filing Date *(day/month/year)*<br>29 August 2000 | Priority Date *(day/month/year)*<br>3 September 1999 |
| International Patent Classification (IPC) or national classification and IPC<br>**Int. Cl.** [7] C22B 3/18 | | |
| Applicant<br>PACIFIC ORE TECHNOLOGY (AUSTRALIA) LTD et al | | |

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets, including this cover sheet.

   [X] This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of **2** sheet(s).

3. This report contains indications relating to the following items:

   - I [X] Basis of the report
   - II [ ] Priority
   - III [ ] Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV [ ] Lack of unity of invention
   - V [X] Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI [ ] Certain documents cited
   - VII [ ] Certain defects in the international application
   - VIII [ ] Certain observations on the international application

| | |
|---|---|
| Date of submission of the demand<br>26 March 2001 | Date of completion of the report<br>30 April 2001 |
| Name and mailing address of the IPEA/AU<br>AUSTRALIAN PATENT OFFICE<br>PO BOX 200, WODEN ACT 2606, AUSTRALIA<br>E-mail address: pct@ipaustralia.gov.au<br>Facsimile No. (02) 6285 3929 | Authorized Officer<br>**MATTHEW FRANCIS**<br>Telephone No. (02) 6283 2424 |

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/AU00/01022

**I. Basis of the report**

1. With regard to the **elements** of the international application:*

☐ the international application as originally filed.

☒ the description, pages **1-16,** as originally filed,
pages , filed with the demand,
pages , received on with the letter of

☒ the claims, pages , as originally filed,
pages , as amended (together with any statement) under Article 19,
pages **17, 18,** filed with the demand,
pages , received on with the letter of

☒ the drawings, pages **1,** as originally filed,
pages , filed with the demand,
pages , received on with the letter of

☐ the sequence listing part of the description:
pages , as originally filed
pages , filed with the demand
pages , received on with the letter of

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).

☐ the language of publication of the international application (under Rule 48.3(b)).

☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, was on the basis of the sequence listing:

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

4. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages

☐ the claims, Nos.

☐ the drawings, sheets/fig.

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report*

International application No.
PCT/AU00/01022

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

| | | |
|---|---|---|
| Novelty (N) | Claims **1-13** | **YES** |
| | Claims **none** | **NO** |
| Inventive step (IS) | Claims **1-13** | **YES** |
| | Claims **none** | **NO** |
| Industrial applicability (IA) | Claims **1-13** | **YES** |
| | Claims **none** | **NO** |

2. Citations and explanations (Rule 70.7)

NOVELTY (N), INVENTIVE STEP (IS):

Claims 1-13: None of the art cited in the International Search Report discloses or suggests the particular combinations of features defined in these claims. Hence the claims are considered both novel and inventive.

**The Claims Defining the Invention are as Follows**

1. A process for the bacterial oxidation of sulphide ores and concentrates characterised in that the ore or concentrate is leached with a mixed bacterial culture operative across a temperature range of about 40 to 65°C, the mixed bacterial culture having been adapted to the ore or concentrate prior to leaching.

2. A process according to claim 1, characterised in that the ore or concentrate is leached with the mixed bacterial culture in a heap leach, tank leach, vat leach or dump leach.

3. A process according to claim 1 or 2, characterised in that the ore or concentrate is either of a base metal, a precious metal or platinum group metal.

4. A process according to any one of claims 1 to 3, characterised in that the sulphide ore or concentrate contains chalcopyrite.

5. A process according to any one of the preceding claims, characterised in that the leach takes place in the temperature range of about 45 to 65°C.

6. A process according to any one of the preceding claims, characterised in that the ore or concentrate is leached at a grind or crush size of greater than $P_{80}$ 75 µm.

7. A process according to claim 6, characterised in that the grind or crush size is greater than $P_{80}$ 90 µm.

8. A process according to any one of the preceding claims, characterised in that the mixed bacterial culture comprises at least two of *Sulfobacillus thermosulfidooxidans*, *Thiobacillus caldus*, and *Thermobacillus ferrooxidans*.

9. A process according to any one of the preceding claims, characterised in that the process of adaptation comprises the addition of both a sample of the ore or concentrate and the mixed bacterial culture to a leach vessel, and leaching the resulting adaptation slurry until the level of targeted metal reporting to solution either reaches 100% or reaches a plateau.

10. A mixed bacterial culture for use in the bacterial oxidation of sulphide ores and concentrates, characterised in that the mixed bacterial culture is not indigenous to the ore or concentrate to be oxidised, the mixed bacterial culture being able to oxidise the ores or concentrates across a range of leach temperatures of about 40 to 65°C, and at a pH of between about 0.5 to 3.0.

11. A mixed bacterial culture according to claim 10, characterised in that the culture comprises at least two of *Sulfobacillus thermosulfidooxidans*, *Thiobacillus caldus*, and *Thermobacillus ferrooxidans*.

12. A mixed bacterial culture according to claim 10 or 11, characterised in that the mixed bacterial culture is able to oxidise chalcopyrite mineral ores and concentrates at grind or crush sizes equal to or greater than $P_{80}$ 75 µm.

13. A mixed bacterial culture according to claim 12, characterised in that the grind or crush size is equal to or greater than $P_{80}$ 90 µm.

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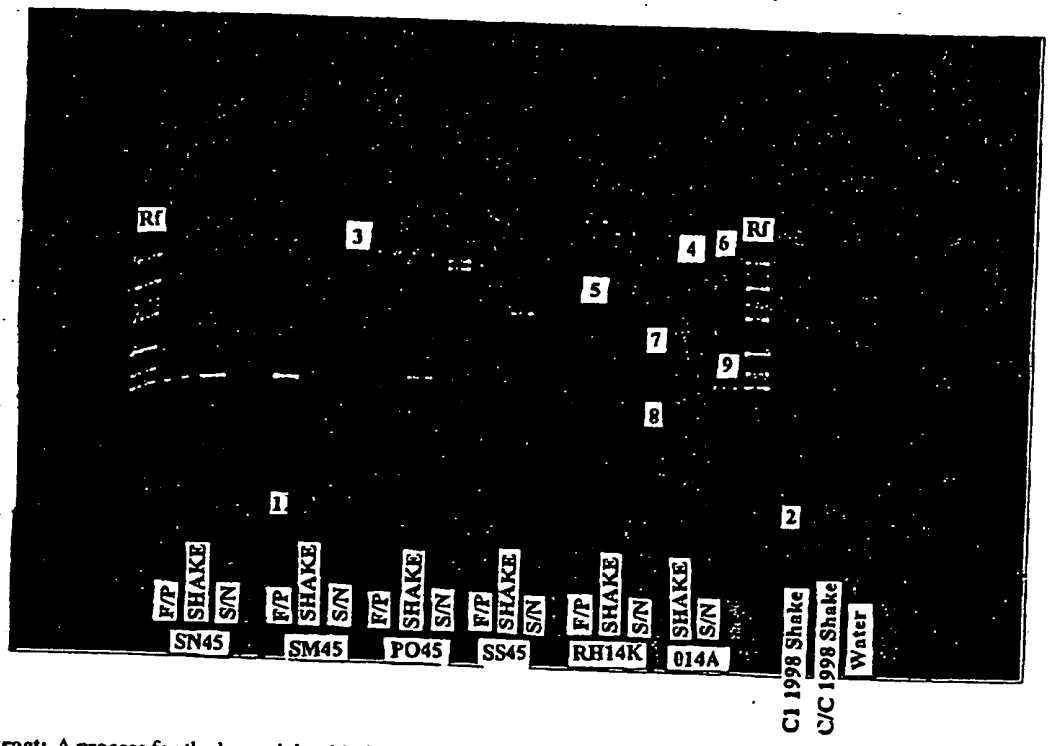
*[Continued on next page]*

(54) Title: IMPROVED BACTERIAL OXIDATION OF SULPHIDE ORES AND CONCENTRATES




(57) Abstract: A process for the bacterial oxidation of sulphide ores and concentrates characterised in that the ore or concentrate is leached with a mixed bacterial culture at a temperature of between about 40 to 650°C, and at a pH of between about 0.8 to 2.2.

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**Published:**
— *With international search report.*

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

# TITLE

"Improved Bacterial Oxidation of Sulphide Ores and Concentrates"

## FIELD OF THE INVENTION

The present invention relates to the improved bacterial oxidation of sulphide ores and concentrates using a mixed bacterial culture.

The bacterial oxidation process of the present invention has particular application in the bacterial oxidation of ores and concentrates containing chalcopyrite.

## BACKGROUND ART

Bacterial oxidation has been used for a number of years in successfully processing arsenopyrite, pyrite, pyrrhotite, covellite and chalcocite ores and concentrates, the one exception to this processing has been the oxidation of chalcopyrite ($CuFeS_2$) ores and concentrates.

Prior art mixes of bacteria used to facilitate oxidation of sulphide ores and concentrates, other than chalcopyrite ores and concentrates, use a variety of suites of bacteria. For example, the mixed bacterial culture employed by Gencor Limited of South Africa comprise predominantly *Thiobacillus ferrooxidans, Thiobacillus thiooxidans* and *Leptospirillum ferrooxidans*. The Gencor cultures consist of a mixed population of mesophilic bacteria, which operate in the temperature range of $35^0C$ to $45^0C$ (Dew & Miller, 1997).

Further, Finnish Patent Application 953488 to Gencor Limited discloses the use of *Thiobacillus ferrooxidans, Thiobacillus thiooxidans* and *Leptospirillum ferrooxidans* to achieve oxidation at a pH of preferably 3 with an ore preferably crushed to below 6mm.

The bacterial culture utilised by BacTech (Australia) Pty Ltd, see for example US Patent 5429659, is a moderately thermophilic bacterial culture operating in the

temperature range of 46°C to 50°C. The culture has been designated "M4" by Barrett et al (1988) and has been described by Nobar et al. (1988) (Brierley and Brans 1994).

The MINBAC process developed by Mintek – Anglo American Corporation based in Randburg, South Africa utilises a mesophilic mixed bacterial culture comprising *Thiobacillus ferrooxidans/Leptospirillum ferrooxidans* (Brierley and Brans 1994).

The bacterial cultures presently used are unable to produce commercially acceptable results for chalcopyrite without either ultra fine milling (p80<20μm) of the ore or concentrate to facilitate bacterial oxidation, or the use of very long leach times to achieve oxidation. Times of over 100 days are not uncommon.

Current trends are moving towards the use of higher temperatures to encourage ferric oxidation. However, the high temperatures employed lead to having to cool post-oxidation and to provide reactors formed of specialised materials, for example surgical grade stainless steel. Both circumstances increase the cost of such an operation.

The process of the present has as one object thereof to overcome the abovementioned problems associated with the prior art, or to at least provide a useful alternative thereto.

The preceding discussion of the background art is intended to facilitate an understanding of the present invention only. It should be appreciated that the discussion is not an acknowledgement or admission that any of the material referred to was part of the common general knowledge in Australia as at the priority date of the application.

Throughout this specification, unless the context requires otherwise, the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

Throughout the specification, an ore is considered material that has been removed from the ground and does not receive any treatment to increase the metal concentration. A concentrate is produced by passing an ore through a treatment process, generally gravity or flotation, in order to increase the concentration of desired metals and decrease the volume of material which is subsequently treated to recover those desired metals.

## DISCLOSURE OF THE INVENTION

In accordance with the present invention there is provided a process for the bacterial oxidation of sulphide ores and concentrates characterised in that the ore or concentrate is leached with a mixed bacterial culture at a temperature of between about 40 to 65$^0$C, and at a pH of between about 0.8 to 2.2.

Preferably, the ore or concentrate is leached with the mixed bacterial culture in a heap leach, tank leach, vat leach or dump leach.

Still preferably, the ore or concentrate is either of a base metal, a precious metal or platinum group ore or concentrate. The sulphide ore or concentrate preferably contains chalcopyrite.

The leach may take place in the temperature range of about 45 to 60$^0$C. The ore or concentrate may preferably be leached at a grind or crush size of up to and greater than $P_{80}$ 90 µm. Still preferably, the grind or crush size is between about $P_{80}$ 75 µm and $P_{80}$ 90 µm.

The mixed bacterial culture preferably comprises one or more of *Sulfobacillus thermosulfidooxidans, Thiobacillus caldus*, and *Thermobacillus ferrooxidans*. The mixed bacterial culture may first be adapted to the particular ore or concentrate. The process of adaption preferably comprises the addition of both a sample of the ore or concentrate and the mixed bacterial culture to a leach vessel, and leaching the resulting slurry until the level of targeted metal reporting to solution either reaches 100% or reaches a plateau.

The adaption slurry is preferably pH adjusted to a pH of between about 1.6 and 1.8.

In accordance with the present invention there is further provided a mixed bacterial culture for use in the bacterial oxidation of sulphide ores and concentrates, characterised in that the mixed bacterial culture is able to oxidise the ores and concentrates at leach temperatures of between about 45 to 65$^0$C, and at a pH of between about 0.8 to 2.2.

Preferably, the culture comprises one or more of *Sulfobacillus thermosulfidooxidans, Thiobacillus caldus*, and *Thermobacillus ferrooxidans.*

The mixed bacterial culture is preferably able to oxidise chalcopyrite mineral ores and concentrates at grind or crush sizes up to and greater than $P_{80}$ 90 µm. The grind or crush size is still preferably between about $P_{80}$ 75 µm and $P_{80}$ 90 µm.

## BRIEF DESCIPTION OF THE DRAWINGS

The present invention will now be described, by way of example only, with reference to the accompanying Figure, in which:-

Figure 1 is a photographic representation of the denaturing gradient gel results for six samples of the mixed bacterial culture of the present invention, processed by three different methods.

## DESCRIPTION

In order to raise a culture capable of processing chalcopyrite ores and concentrates a bacterial culture indigenous to a chalcopyrite mineral was sought. Indigenous bacterial cultures are typically superior to modified isolated cultures as the indigenous culture has already been adapted to the toxins and mineral components associated with a particular ore resulting in more effective and resilient bacterial strains.

Bacterial cultures indigenous to chalcopyrite ores were cultivated and tested for their ability to oxidise both their native ore/concentrate and other chalcopyrite ores and concentrates. During this program of work a culture was raised from a chalcopyrite ($CuFeS_2$) concentrate obtained from a base metal ore found in New Brunswick, Canada. Following the isolation of the bacterial culture, testing of the culture has taken place on both its' native ore and concentrate, and on a variety of other ores and concentrates. Additions to the original culture have taken place as, during testing of the culture of different materials, any native bacteria capable of operating under the parameters of the test and being able to operate competitively with the introduced culture have not only survived but have thrived in the environment. In this way any bacteria native to the ore or concentrate being tested have been incorporated into the culture. In addition, the culture has been grown successfully at different temperatures ranging from 40$^0$C to 65$^0$C and at varying levels of acidity with pH levels ranging from 0.8-2.2. Successful testing of the culture has taken place in both aerated agitated stirred tank reactors and in aerated columns to facilitate column leaching. Successful testing of the culture took place at a variety of temperatures and on a variety of ores and concentrates.

The mixed bacterial culture of the present invention consists of a variety of iron, sulphide and sulphur oxidising bacteria capable of working at temperatures of up to 65$^0$C and at pH ranges of between 0.8 and 2.5. The mixed bacterial culture may include, but is not limited to, *Sulfobacillus thermosulfidooxidans, Thiobacillus caldus, Thermobacillus ferrooxidans* and a number of as yet unidentified bacterial species. The mixed bacterial culture of the present invention has been deposited at the Australian Government Analytical Laboratories under Accession No. NM99/07541.

Example

Prior to testing any material the stock bacterial culture is first adapted to the material of interest. This is facilitated by placing 2700 ml of modified 0K solution (1.0 g/L ammonium sulphate, 0.5 g/L di-potassium orthophosphate, 0.16 g/L magnesium sulphate heptohydrate, pH 1.6 – 1.8) into an agitated aerated stirred tank reactor heated to the required temperature. To the modified 0K medium a

150g sample of milled ($P_{80}$<45 µm) test material is added and the pH adjusted down to between 1.6 and 1.8 if necessary using concentrated sulphuric acid. To this slurry a 300 ml slurry sample of the stock inoculum is introduced. The agitated reactor is aerated at a rate of 1L/min/L slurry. The adaption is continued until the level of relevant metals reporting to solution reaches either 100% or reaches a plateau. Solution samples are assayed for metal levels in solution through the use of an ICP, where appropriate the pH of the slurry is adjusted with concentrated sulphuric acid so that the pH is between 1.6 and 1.8. In addition to metal levels reporting to solution the progress of the adaption/test is further monitored according to its oxidation reduction potential (ORP), ferrous concentration and dissolved oxygen concentration (DO).

Once the culture has adapted to the material of interest it is used as an inoculum for further agitated aerated stirred tank reactor tests or as an inoculum for heap or column tests. The adapted bacterial inoculum is diluted further through the addition of an acidic basic nutrient solution containing ammonium sulphate, potassium orthophosphate and magnesium sulphate. The concentration of these nutrients in solution may vary between laboratory tests and commercial operation and between different commercial operations. In all cases the progress of oxidation is monitored through the levels of metals reporting to solution, pH, ORP, ferrous concentration and DO content.

The mixed bacterial culture of the present invention was tested on a range of chalcopyrite bearing samples from various locations around the world. Table 1 below illustrates the mineralogy and origin of the chalcopyrite concentrates and ores tested using the bacterial culture of the present invention.

TABLE 1

| Sample | Mineralogy | Origin |
|---|---|---|
| A | Chalcopyrite copper concentrate. | USA |
| B | Molybdenum concentrate with low levels of copper in chalcopyrite. | Canada |
| C | Concentrate comprising predominantly chalcopyrite (35%) and cubanite (17%) with lesser quantities of pyrrhotite (10%) | Canada |

| | | |
|---|---|---|
| | and minor amounts of pentlandite (3%) and sphalerite (3%). | |
| D | Copper Nickel concentrate in which copper is present as both chalcopyrite (18.5 – 28.5%) and cubanite (15.8 – 30.8%). Nickel is present as pentlandite (17.7 – 10.4%) and occasionally replaced as violarite. | USA |
| E | Three copper concentrates consisting of chalcopyrite, pyrite and minor amounts of bornite. | Canada |
| F | Copper concentrate consisting of chalcocite (14%), chalcopyrite (10%), bornite (1%) and pyrite (1%). | South Africa |
| G | Samples i and iii are ore samples and sample ii is a concentrate sample. The sulphide minerals are predominantly pentlandite, chalcopyrite and pyrrhotite. | Western Australia |

General test procedure

All tests on mineral samples were conducted in agitated aerated tank reactors. Each test had a solids density of 10%w/v and was aerated by sparging at a rate of 1L air per minute per litre of slurry in the reactor. The evaporative losses due to the heating and aeration of the slurry were made up prior to sampling the tests. This was accomplished through the addition of tap water. All slurries were made up in a proprietary nutrient media with a starting pH of 1.0. Sampling involved assaying the solution for iron, copper and other relevant metal ions. In addition, the oxidation-reduction potential (ORP), pH, ferrous iron and dissolved oxygen levels were also monitored and recorded. Copper release was used to monitor the progress of the test and once this reached a stable plateau or attained approximately 100% of the copper reporting to solution the test was deemed complete. Once complete the pulps were pressure filtered, the final leach liquor assayed and the filter cake washed with acidified water and dried. The dried filter cake was weighed and the residue assayed in order to conduct a metallurgical balance.

The results from head analysis, particle size analysis and the results following oxidation are summarised and displayed in Table 2.

TABLE 2

| Sample | Head Analysis | | | | T °C | Days Leached | Results after leaching |
|---|---|---|---|---|---|---|---|
| | Particle Size Analysis | Fe % | Cu% | S total % | | | % Cu Leached |
| A | $P_{81}$<90µm | 28.60 | 29.40 | 32.1 | 48 | 36 | 96.6 |
| B | $P_{85}$<90µm | 2.85 | 1.95 | 37.6 | 48 | 20 | 96.9 |
| C | $P_{80}$<75µm | 27.30 | 20.97 | 27.37 | 48 | 22 | 98.0 |
| D | $P_{80}$<75µm | 26.30 | 12.80 | 25.1 | 48 | 27 | 95.0 |
| E i | $P_{84}$<75µm | 15.00 | 2.87 | 13.9 | 48 | 28 | 99.3 |
| E iii | $P_{78}$<75µm | 26.6 | 4.62 | 34.4 | 48 | 28 | 99.3 |
| F | $P_{80}$<43µm | 6.79 | 28.5 | 10.2 | 60 | 14 | 95.3 |
| G i | $P_{80}$<75µm | 17.8 | 1.18 | 7.88 | 48 | 14 | 98.8 |
| G ii | $P_{80}$<75µm* | 45.1 | 6.82 | 34.8 | 50 | 10 | 98.0 |
| G iii | $P_{80}$<75µm | 18.2 | 0.1 | 3.11 | 50 | 8 | 97.3 |
| H | $P_{80}$<75µm* | 23.8 | 19.7 | 36.7 | 48 | 15 | 99.2 |

*nominal sizing of the "as received" concentrate.

A number of samples of the adapted bacterial culture of the present invention have been grown at temperatures ranging from 35°C to 65°C, samples from each of the cultures have been removed and prepared for identification using 16SrRNA sequencing. Preparation of the samples prior to RNA sequencing was undertaken using three different methods. The methods used and the results obtained from 16SrRNA sequencing are as follows.

Methods

Six samples (designated SN 45, P45, SS 45, RH 14K, and 014A) were tested.

The samples were mixed on a hand shaker at maximum speed for 30 minutes and processed as follows:

**A Shaken.** 500 µl of the shaken sample was immediately sedimented onto glass fibre filters (#30 Sliecher and Schuell, Keene, NH) in a 1.5 ml microtube by centrifugation at 14Krpm for 4 minutes. The supernatant was carefully removed, and the sedimented material was washed twice in 1 ml of tissue culture grade water.

**B. Fast Prep.** 500 µl was immediately removed and homogenized using a Savant BIO 101 Fast Prep machine (BioCan Scientific) at speed 4 for 20 seconds. The homogenates were sedimented and washed as described above.

**C. Supernatant.** Following shaking, the samples were allowed to sit for 5 minutes to allow the particulate matter to settle to the bottom of the tubes. 500 µl of the supernatant was then sedimented and washed as previously described.

RNA was extracted from all samples using InstaGene Matrix (BioRad, Hercules, CA) as per manufacture's instructions. The RNA concentration was determined by uv spectrophotometry ($A_{260}$) and 50 ng were added to the PCR reaction mixture with a final concentration of 2mM magnesium ion, 100 uM dNTP, 0.32 µm each primer and 0.625 units of Taq Gold Polymerase. The universal primers p515f and p806r (Relman 1993) were used to amplify an approximately 300bp segment of the 16S ribosomal RNA gene. The forward primer was modified with a 40bP GC rich sequence that terminated the migration of the amplified product at various concentrations of urea/formamide within a denaturing gradient gel (Sheffield et al. 1989; Muyzer et at. 1993) Bands of interest were cut from the denaturing gels and purified amplified product was subjected to cycle sequencing using Big Dye Terminator extension from the reverse primer using the conditions recommended (PE Applied Biosystems). Sequence determination was performed on a 310 Genetic Analyser (PE Applied Biosystems). Sequence comparisons were conducted using the basic local alignment search tool (BLAST; Altschul et al. 1990).

Results

Each of the three samples processing methods resulting in a different profile for the same sample, as shown in Figure 1. Nine predominant bands were selected for sequencing. The 300bp segments sequenced had the closest match with partial sequences of the 16S rRNA gene of the bacterial species listed in the BLAST result column. A larger 16S segment would have to be sequenced for more precise identification.

A summary of the BLAST search results for the 300 base pair 16S rRNA gene segments sequenced is shown in Table 3. The numbers in parentheses refer to the % homology between the unknowns and their closest matches.

TABLE 3

| **Band** | **sequenced from** | **band with same mobility** | **BLAST result** |
|---|---|---|---|
| 1 | SM45-fast prep | SN45-shaken, C1 (1998)-shaken C/C (1998)-shaken | *Sulfobacillus thermosulfidooxidans (98%)* |
| 2 | C1 (1998)-shaken | SM45-fast prep SN45-shaken C/C (1998)-shaken | *Sulfobacillus thermosulfidooxidans (98%)* |
| 3 | SN45-supernatant | 014A-shaken | *Streptococcus salivaritus (100%)* *Streptococcus thermophilus (100%)* |
| 4 | 014A (50$^0$C)-shaken | SN45-supernatant | *Streptococcus salivaritus (100%)* *Streptococcus thermophilus* |

| | | | |
|---|---|---|---|
| | | | *(100%)* |
| 5 | RH14K (60$^0$C)-shaken | | *Caulobacter sp. (99%)*<br>*Asticcacaulus exentricus (99%)* |
| | | | *Asticcacaulis biprothecum (99%)*<br>*Psuedomonas echinoides (97%)*<br>*Sphingomonas paucimobilus (98%)* |
| 6 | 014A (50$^0$C)-shaken | | *Psuedomonas echinoides (98%)*<br>*Sphingomonas trueperi (97%)*<br>*Caulobacter sp. (97%)*<br>*Asticcacaulis biprothecum (97%)* |
| 7 | RH14K (60$^0$C)-supernatant | SN45-fastprep/shaken<br>SM4-shaken/supernat.<br>PO45-fastprep/shaken<br>SS45-fastprep/shaken/supernatant<br>RH14K-shaken | *Enterobacter sp (80%)* |
| 8 | RH14K (60$^0$C)-supernatant | PO45-fastprep/shaken/supernatant<br>SS45-supernatant | *Unidentified bacterium (97%)*<br>*Beta proteobacterium (98%)*<br>*Denitrifying Fe<II> oxidizing bacteria (97%)* |

| | | | |
|---|---|---|---|
| 9 | 014A (500C)-supernatant | SN45-fastprep/shaken/supernatant<br><br>SM45-fastprep<br><br>014A shaken | *Thermobacillus ferrooxidans (96%)* |

It is envisaged that bacterial species can be omitted or substituted to the mixed culture outlined above in order to facilitate its operation at different temperatures. For example, *Thiobacillus thiooxidans* a sulphur oxidising bacteria may be substituted for *Thiobacillus caldus* at lower temperatures.

It is envisaged that the materials the mixed bacterial culture of the present invention may be used to treat include base metal ores and concentrates (copper, nickel, cobalt zinc etc), precious metal ores and concentrates (gold and silver) and platinum group metal (PGM) ores and concentrates. It is further envisaged that the culture may be used in a heap leach, tank leach, vat leach or dump leach oxidation.

Heap leaching is by far the most commonly utilised bacterial process for recovering copper from the more easily oxidised secondary copper minerals such as covellite and chalcocite. The process involves stacking crushed ore onto a specially prepared impermeable pad. The pad is designed so that the pregnant liquor draining from the heap collects at a point from which it is drained to a collection pond. Metals are recovered from the pregnant liquor solution either via precipitation, solvent extraction and/or electrowinning.

In order for successful heap leaching to take place it is essential to maintain the integrity of the heap. The main factor determining the heaps stability is the crush size of the ore. Crushing of the ore must take place to an extent where the ore is fine enough to allow good lixiviant percolation through the heap without excessive channelling taking place whilst also maintaining void spaces essential for good air dispersion and lixiviant drainage. If the ore is crushed too finely percolation through the heap may be very slow. Insufficient void spaces will be present and

inefficient drainage of the heap will occur resulting in pooling in the heap and a high phreatic head. If on the other hand the ore size is too coarse, drainage of the heap will be fast and the level of metals in solution will be low, in addition the structure of the heap may fail as the ore is broken down through biological and chemical processes. In many cases the crushed ore is agglomerated with binders, sulphuric acid and water prior to stacking, the result being a more uniform particle size and acid distribution throughout the heap.

Prior to stacking the heap a drainage layer is usually placed on the pad, this is generally composed of unreactive rock such as quartzite and ensures adequate drainage of the pregnant liquor. Heaps are irrigated with acidified bacterial liquor which acts as the lixiviant for leaching of the copper from the ore. The bacteria employed in heap leaching are generally aerobic and therefore require oxygen. This may be forced into the heap by means of low pressure blowers or air may be sucked into the heap due to a chimney effect that occurs as bacteria oxidise ore and create heat.

The Geocoat process is a variation on heap leaching and has been marketed by US company Geobiotics. The process involves producing a concentrate from the sulphidic ore, coating this onto crushed, sized rock and producing a heap that can be subjected to bacterial oxidation.

Dump leaching is very similar to heap leaching and is generally reserved for lower grade ores. Often dump leaching will be considered an as accompanying process to heap leaching rather than a stand alone project in its own right. Essentially, where waste or low grade rock is to be mined and stockpiled anyway, with little ground preparation beforehand, some value can be extracted from the material. Indigenous bacteria will be present in the heap and all that is required is to promote their activity. This is done by the addition of acid and nutrients to the irrigation solution, such as with heap leaching. The difference is in the cost.

Little or no crushing will be performed prior to stacking. Only the bare minimum of pad preparation will be performed. There will be no forced aeration.

Vat leaching can be considered to be intermediate between heap leaching and tank leaching in terms of cost, sophistication and efficiency. It is a process in which the material to be treated is fully immersed in the leach solution but is not agitated, at least not to any significant extent, though some agitation due to the air and/or solution flow may take place. The process has the advantage over heap or dump leaching in that complete wetting of the mineral surfaces is achieved and channelling is avoided. Finer crush sizes can also be handled better in a vat, though there is still a limit to the fineness imposed by the need for permeability by both the air and solution. Beyond this limit, it becomes necessary to suspend the material in the solution. If the vats are to be single use only, they can be constructed as lined dams, sloped to one corner to allow circulation and recovery of the leach liquor. Multiple use vats would need to be of a more robust construction such as concrete or brick. Aeration would be by submerged pipe or could otherwise by accomplished by intermittently draining the vat and allowing air to be drawn into the ore by the retreating liquor.

Tank leaching, as the name suggests, entails the bacterial leaching of aerated mineral slurries in agitated tanks. The technology was pioneered by Gencor and is now well developed for the treatment of gold. It is envisaged that the technology would be very similar for base metal bio-leaching, but to date a system for copper has not been commercially developed.

Available results indicate that the costs associated with ultra-fine milling of the concentrate ($P_{80}$ <30 μm) can be expected to make the capital and operating costs too high.

The process of the present invention is capable of operating at a wide range of temperatures, thereby leading to a reduction in costs associated with cooling bacterial oxidation systems. The process is further capable of oxidising all forms of chalcopyrite, and at crush sizes that need not incur significant capital and operating costs.

Modifications and variations such as would be apparent to the skilled addressee are considered to fall within the scope of the present invention.

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## CLAIMS

1. A process for the bacterial oxidation of sulphide ores and concentrates characterised in that the ore or concentrate is leached with a mixed bacterial culture at a temperature of between about 40 to 65$^0$C, and at a pH of between about 0.8 to 2.2.

2. A process according to claim 1, characterised in that the ore or concentrate is leached with the mixed bacterial culture in a heap leach, tank leach, vat leach or dump leach.

3. A process according to claim 1 or 2, characterised in that the ore or concentrate is either of a base metal, a precious metal or platinum group ore or concentrate.

4. A process according to any one of claims 1 to 3, characterised in that the sulphide ore or concentrate contains chalcopyrite.

5. A process according to any one of the preceding claims, characterised in that the leach takes place in the temperature range of about 45 to 60$^0$C.

6. A process according to any one of the preceding claims, characterised in that the ore or concentrate is leached at a grind or crush size of up to and greater than $P_{80}$ 90 µm.

7. A process according to claim 6, characterised in that the grind or crush size is between about $P_{80}$ 75 µm and $P_{80}$ 90 µm.

8. A process according to any one of the preceding claims, characterised in that the mixed bacterial culture comprises one or more of *Sulfobacillus thermosulfidooxidans, Thiobacillus caldus*, and *Thermobacillus ferrooxidans*.

9. A process according to any one of the preceding claims, characterised in that the leach is carried out over a period of between 8 to 36 days.

10. A process according to any one of the preceding claims, characterised in that the mixed bacterial culture is first adapted to the particular ore or concentrate.

11. A process according to claim 10, characterised in that the process of adaption comprises the addition of both a sample of the ore or concentrate and the mixed bacterial culture to a leach vessel, and leaching the resulting slurry until the level of targeted metal reporting to solution either reaches 100% or reaches a plateau.

12. A process according to claim 11, characterised in that the adaption slurry is pH adjusted to a pH of between about 1.6 and 1.8.

13. A mixed bacterial culture for use in the bacterial oxidation of sulphide ores and concentrates, characterised in that the mixed bacterial culture is able to oxidise the ores and concentrates at leach temperatures of between about 45 to 65$^0$C, and at a pH of between about 0.8 to 2.2.

14. A mixed bacterial culture according to claim 13, characterised in that the culture comprises one or more of *Sulfobacillus thermosulfidooxidans*, *Thiobacillus caldus*, and *Thermobacillus ferrooxidans*.

15. A mixed bacterial culture according to claim 13 or 14, characterised in that the mixed bacterial culture is able to oxidise chalcopyrite mineral ores and concentrates at grind or crush sizes up to and greater than $P_{80}$ 90 µm.

16. A mixed bacterial culture according to claim 15, characterised in that the grind or crush size is between about $P_{80}$ 75 µm and $P_{80}$ 90 µm.

17. A mixed bacterial culture according to any one of claims 13 to 16, characterised in that the leach is carried out over a period of between 8 to 36 days.

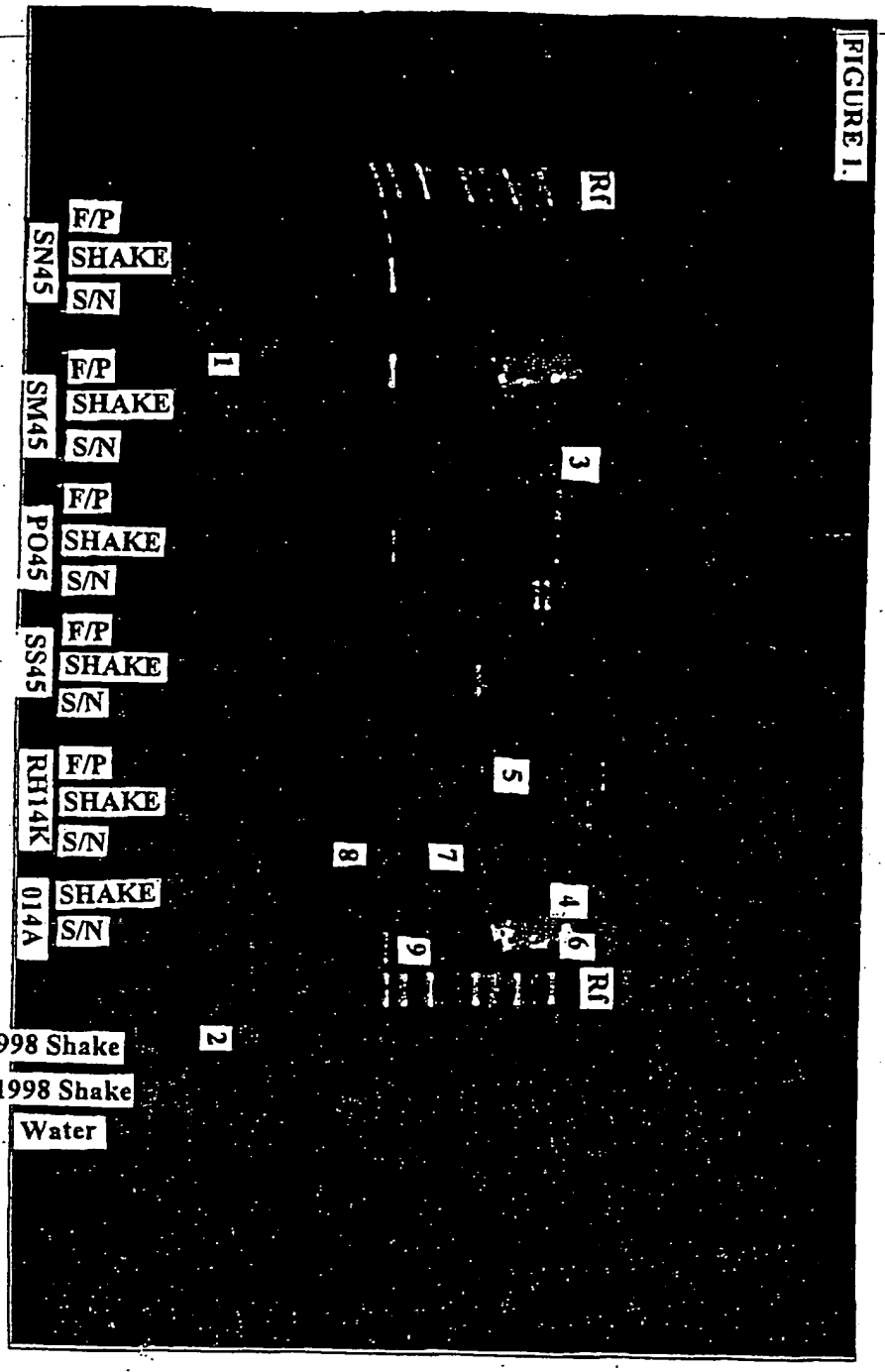


FIGURE 1.